

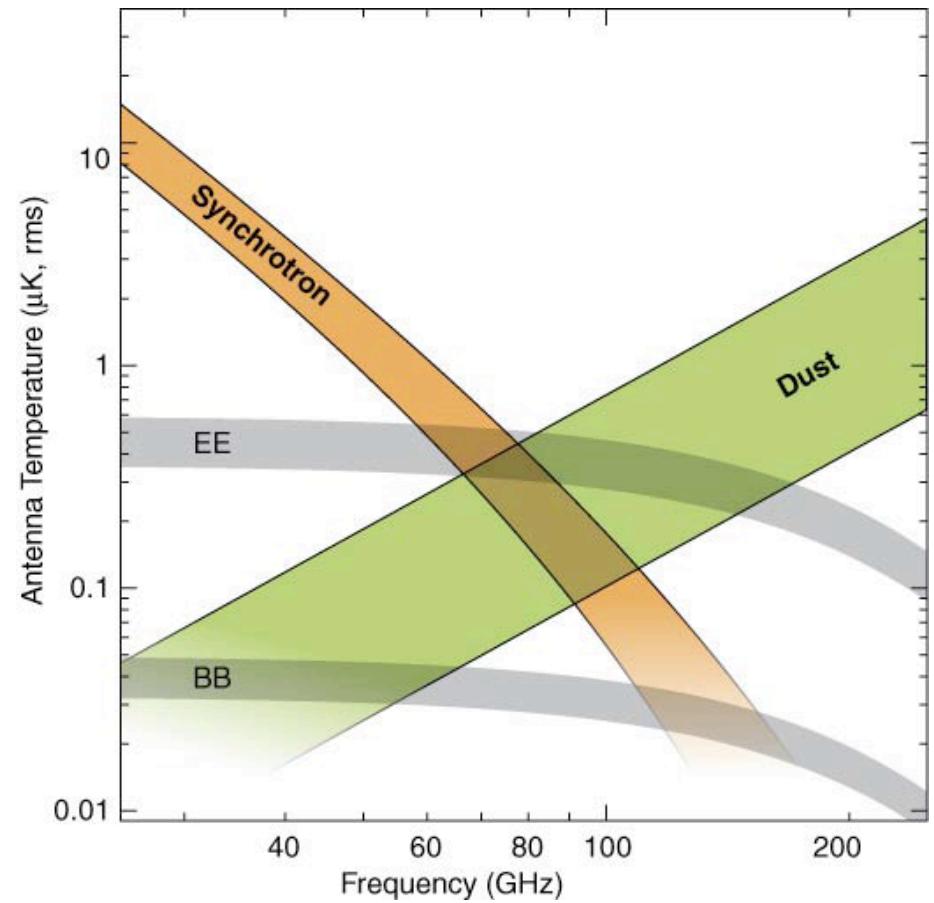
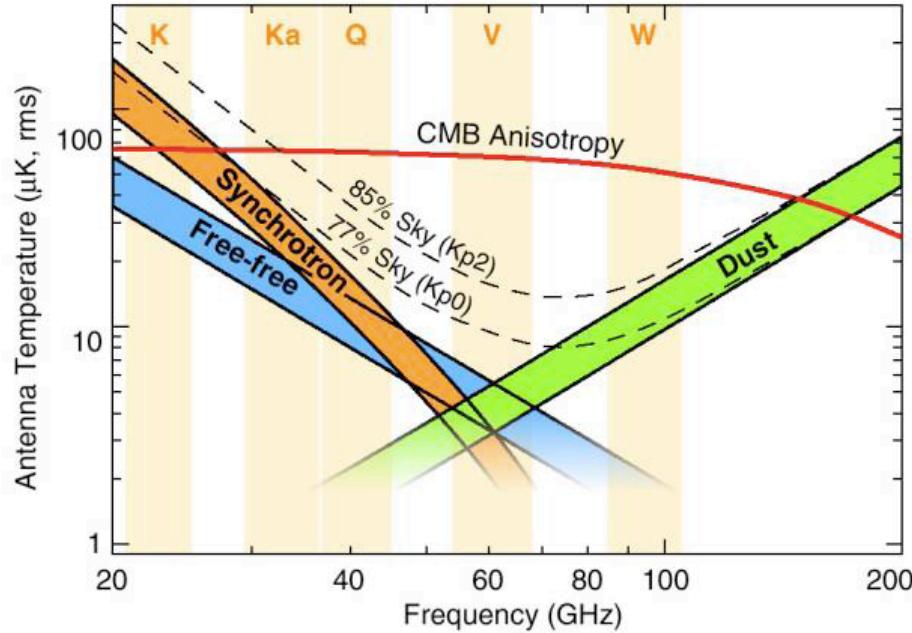
# CMB Polarization Science Goals and where QUIET fits in

CMB spectrum, and power spectrum  
E-modes  
B-modes  
Coherent HEMT vs. TES bolometers  
Upcoming experiments

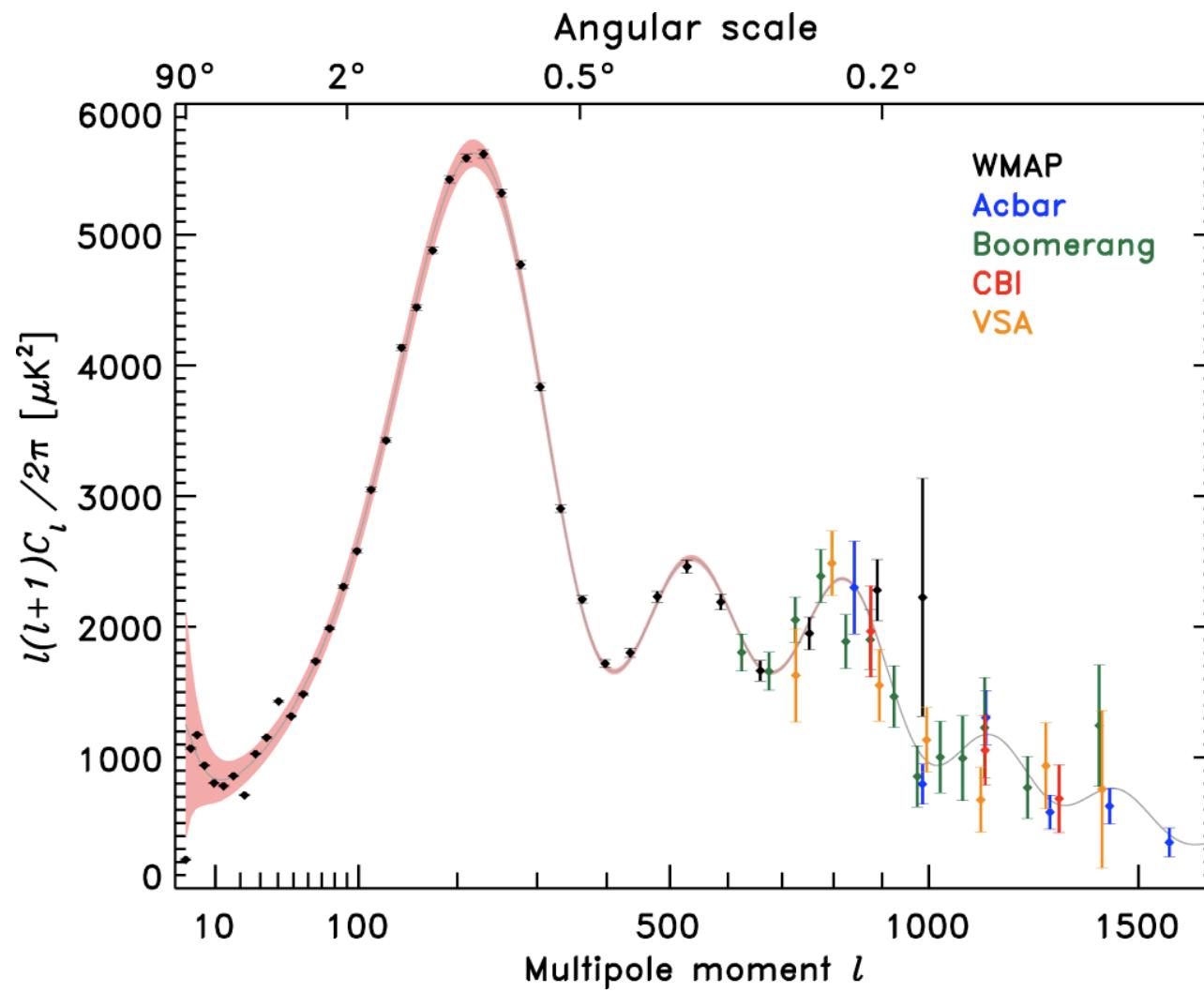
# References

- *Task Force On Cosmic Microwave Background Research – Final Report*
- *The Cosmic Microwave Background for Pedestrians: A Review for Particle and Nuclear Physicists.* Dorothea Samtleben, Suzanne Staggs, Bruce Weinstein
- *QUIET - Measuring The CMB Polarization With Coherent Detector Arrays.* D. Samtleben

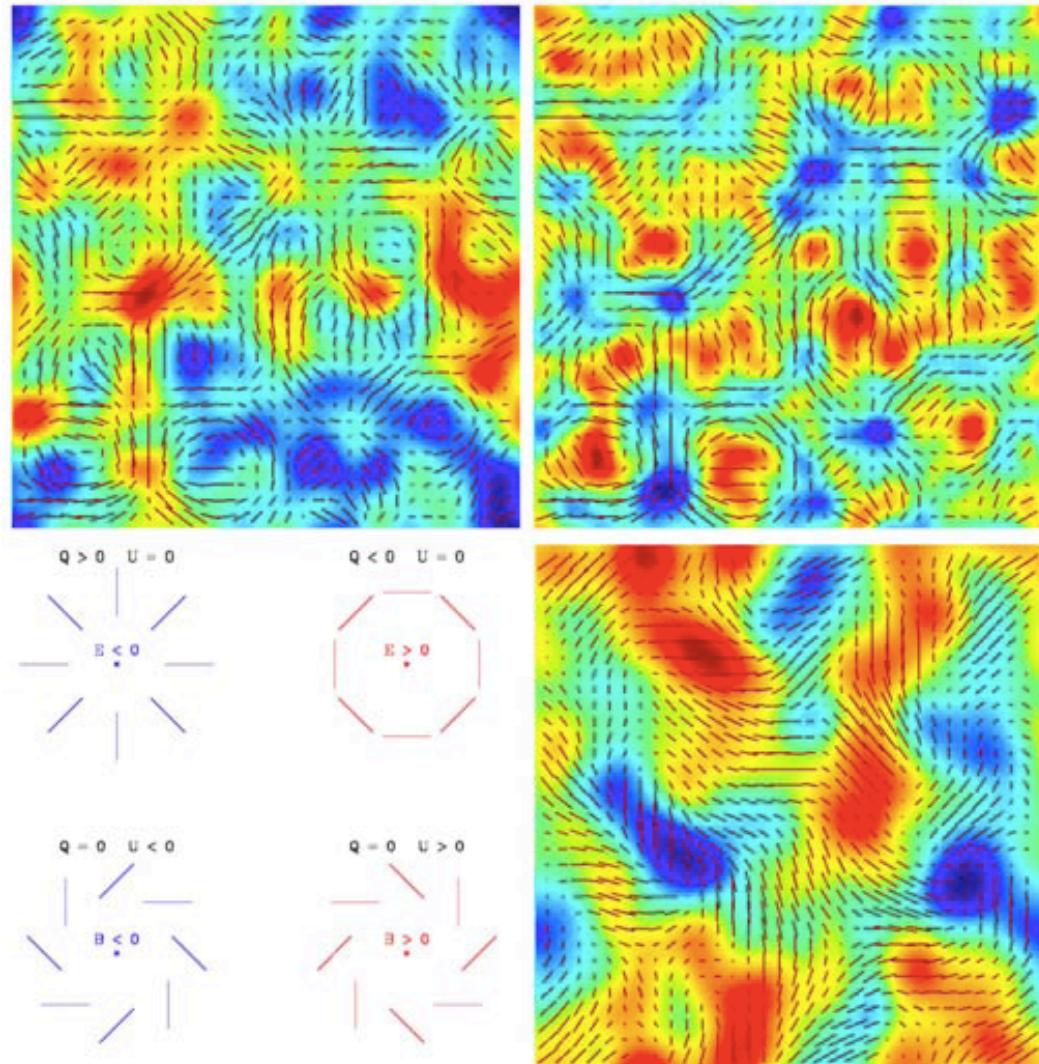
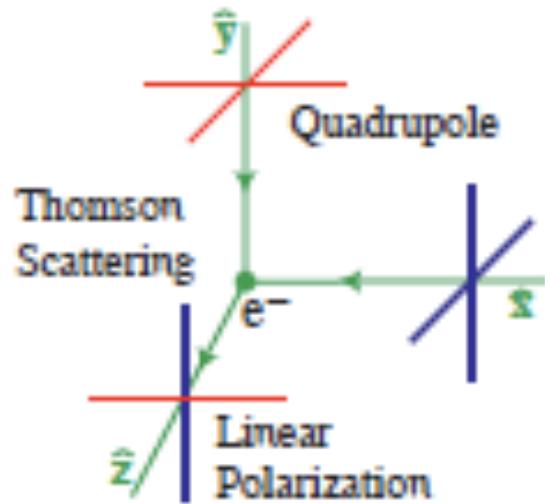
# CMB spectrum



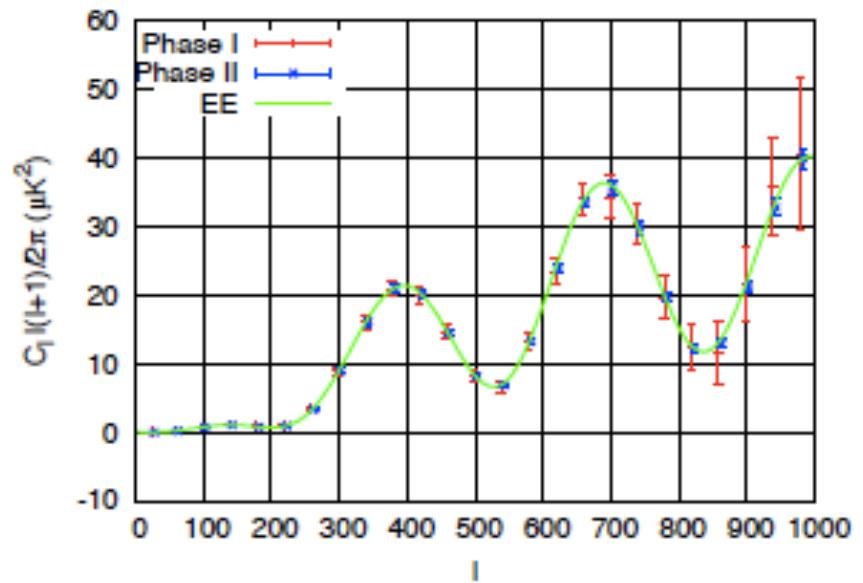
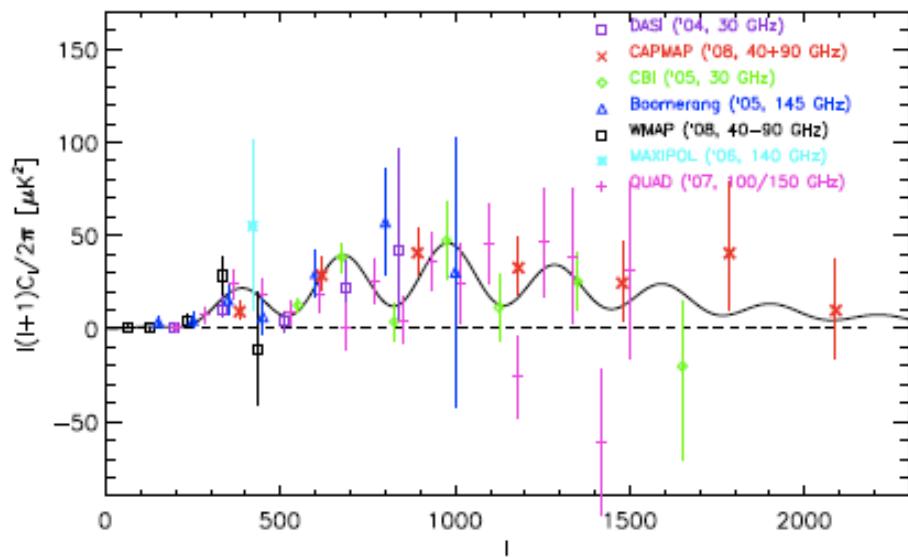
# CMB power spectrum (TT)



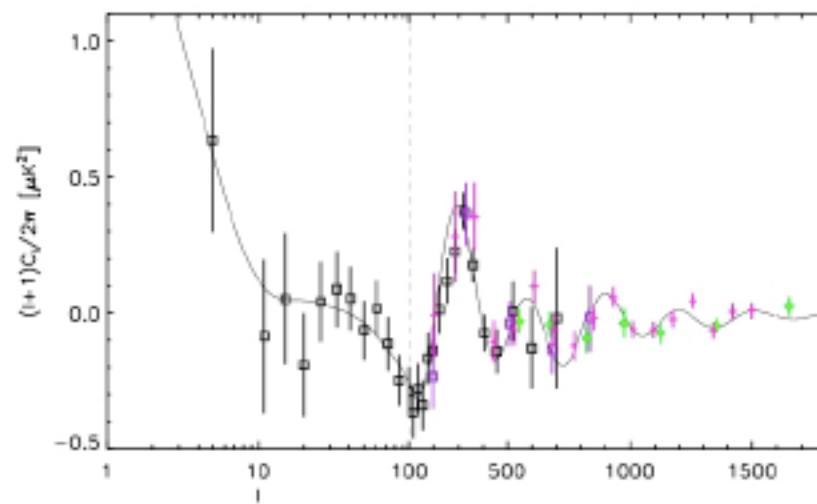
# E-modes and B-modes, Q and U



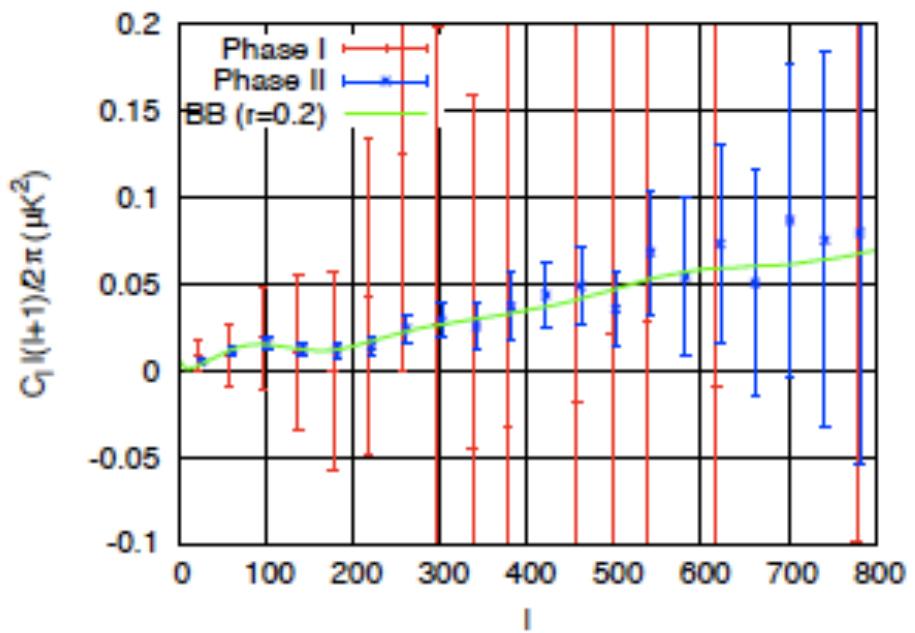
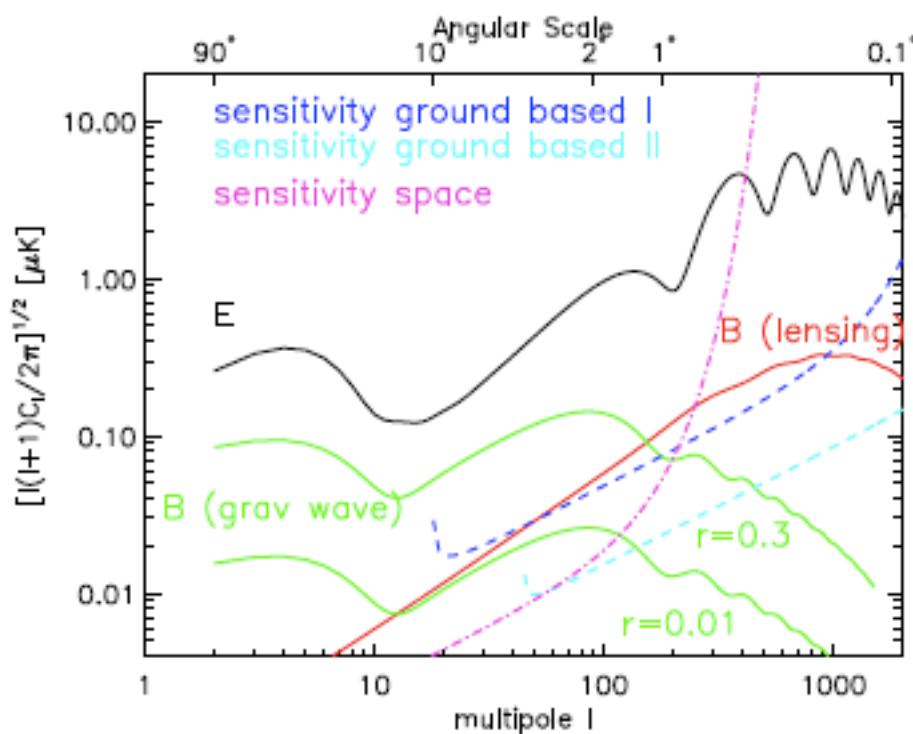
# EE



# TE



# BB



# Experimental Parameters

Mission	WMAP 100GHz	Planck 100GHz	CMBPOL
Duration	8 years	1.2 years	2–8 years
Detectors/Band	8	8	150–1000
NET/BLIP <sub>CMB</sub>	~60	~4	~2
NET/1°x1°	≈ 6μK	≈ 1μK	20–100nK

Parameter	Effect	Goal	Method
Cross-Polar Beam response	E → B	< 0.003	Rotate Instrument, Wave Plate
Main lobe ellipticity (0.5° beam)	dT → B	< 10 <sup>-4</sup>	Rotate Instrument, Wave Plate
Polarized sidelobes (response at Galaxy)	dT → B	< 10 <sup>-6</sup>	Baffles/shielding/measure
Instrumental polarization	dT → B	< 10 <sup>-4</sup>	Rotate Instrument, Wave Plate
Polarization angle	E → B	< 0.2 °	Measure
Relative pointing (of differenced samples)	dT → B	< 0.1 "	Dual-polarization pixels
Relative calibration	dT → B	< 10 <sup>-5</sup>	Modulators
Relative calibration drift (scan synchronous)	T → B	< 10 <sup>-9</sup>	Modulators
Lyot Stop Temperature (10% spill, scan synch.)	dT <sub>opt</sub> → B	dT <sub>opt</sub> < 30 nK	Measure
Cold stage T drifts (scan synch.)	dT <sub>CS</sub> → B	dT <sub>CS</sub> < 1 nK	Improve uniformity, measure

# Comparison of TES bolometers and HEMT coherent sensors

Freq.	2005 <sup>(b)</sup>		2010 <sup>(c)</sup>	
	Bolometer	HEMT $\sqrt{2}$	Bolometer	HEMT $\sqrt{2}$
[GHz]	$[\mu\text{K}_{\text{cmb}} \sqrt{s}]$	$[\mu\text{K}_{\text{cmb}} \sqrt{s}]$	$[\mu\text{K}_{\text{cmb}} \sqrt{s}]$	$[\mu\text{K}_{\text{cmb}} \sqrt{s}]$
30	–	93	57	48
40	–	115	51	51
60	–	175	44	60
90	67	224	40	75
120	–	–	40	93
150	48	–	43	–
220	68	–	64	–
350	224	–	220	–

# QUIET and other Experiments

- QUIET: HEMTs, 40 and 90 GHz. (1 HEMT equivalent to 2 TES)
  - ~100 sensors late 2008. 28' and 13'
  - ~1000 for Phase-II.  $R \sim 0.01$ . 8' and 4'

Other upcoming ground-based experiments: TES Bolometers, 90, 150, and 220 GHz (typically)

- BICEP/BICEP-2/Keck. 45'  $R \sim 0.01$ 
  - 90 / 500 / 1500 sensors
  - Now / 2009 / 2010
- Clover: 576 sensors, 2010. 5.5'  $R \sim 0.03$
- PolarBear: 4', 600 sensors,  $R \sim 0.015$
- BRAIN: bolometric interferometer, DOME-C. 1000 sensors. Low-l. 2011.  $R \sim 0.01$
- SPT: Now, 1000 unpolarized sensors, ~ 1'. Future: SPTpol

Balloon-borne experiments

- EBEX: 1320 sensors, 2' to 8', 2009,  $R \sim 0.02$
- Spider: 3000 sensors, 40', 2010,  $R \sim 0.01$
- Piper: 5120 sensors, 15', 2013,  $R \sim 0.007$